

# **Non-Radioisotope Power Systems for Sunless Solar System Exploration Missions**

**PI: Michael Paul**

**The Applied Research Lab at Penn State**





Team Leader	Michael Paul, PSU
COMPASS Lab Leader	Steve Oleson, GRC
Science, PI	James Kasting (PSU), Geoff Landis, GRC
Robotic elements	Geoff Landis (GRC), Gary Hunter (GRC)
HERRO Venus Advisor/HERRO Venus PI	George Schmidt, GRC / Geoff Landis GRC
System integration / CONOPS/PEL	Carl Sandifer (GRC)
Mission Trajectory Design	John Dankanich, Aerodank Inc.
Guidance, navigation, and control	Michael Martini, QNA Corp.
Propulsion / Cryogenics	James Fittje, QNA Corp., David Chato, GRC
Mechanical systems	John Gyekenyesi, ASRC, David McCurdy, ASRC
Thermal	Tony Colozza, QNA Corp.
Power	Paul Schmitz PCS, Timothy Miller (PSU)
Configuration and data handling	Glenn Williams, GRC
Communications	Chuck Sheehe, GRC
Configuration	Tom Packard, QNA Corp.
Cost	Jon Drexler

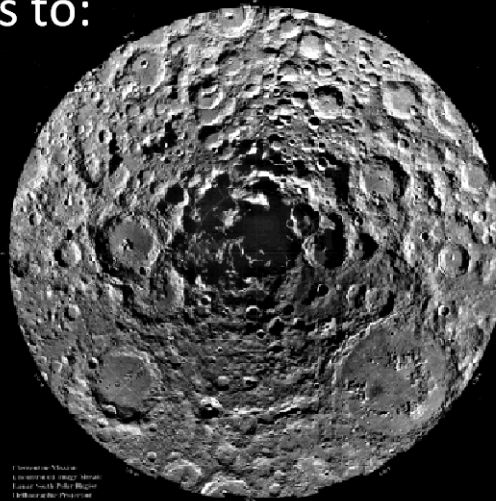


# Non-Radioisotope Power Systems For Sunless Solar System Explor/ on Missions

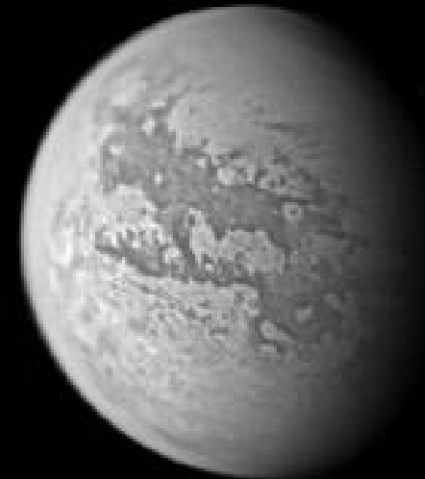
Can metal-combus/ on power systems enable mid-dura/ on explora/ on missions to:



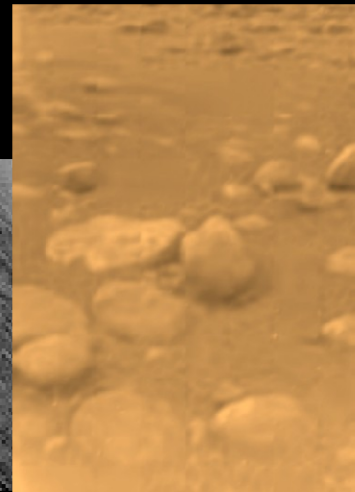
Venus?



The Aitken Basin?



Titan?

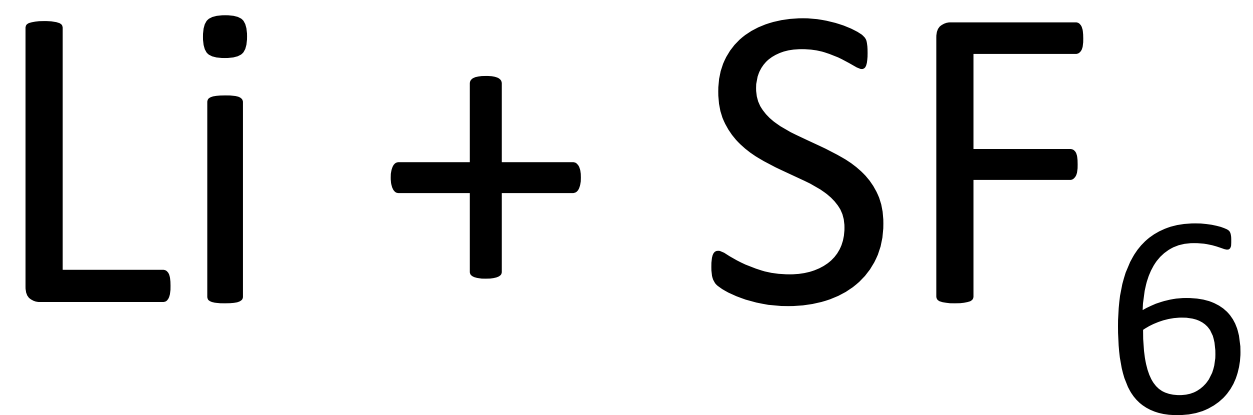


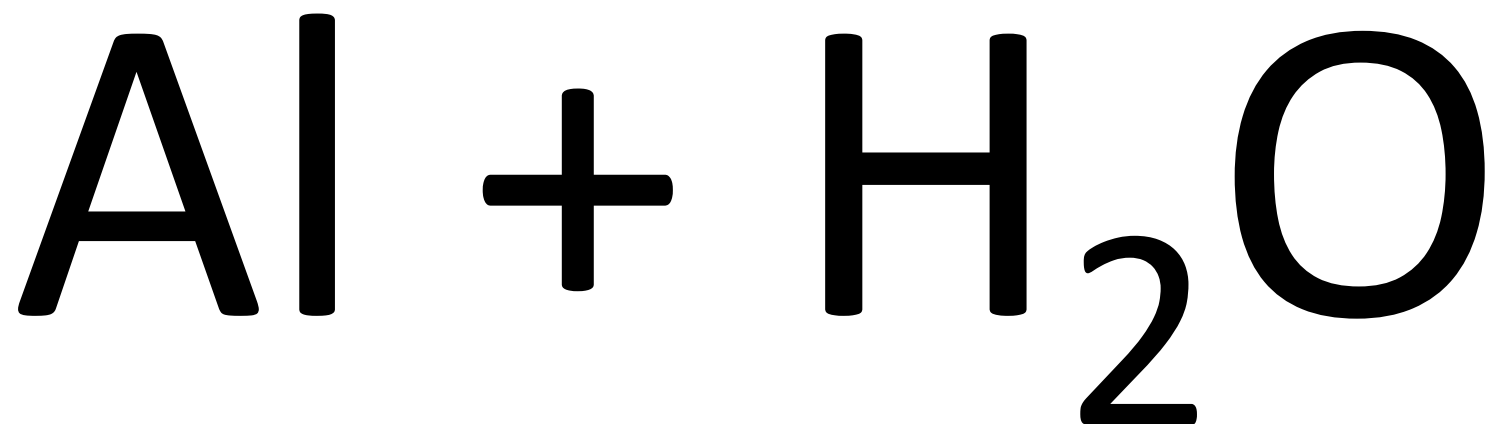
A 2011 NASA Ins/ tute for Advanced Concepts Proposal

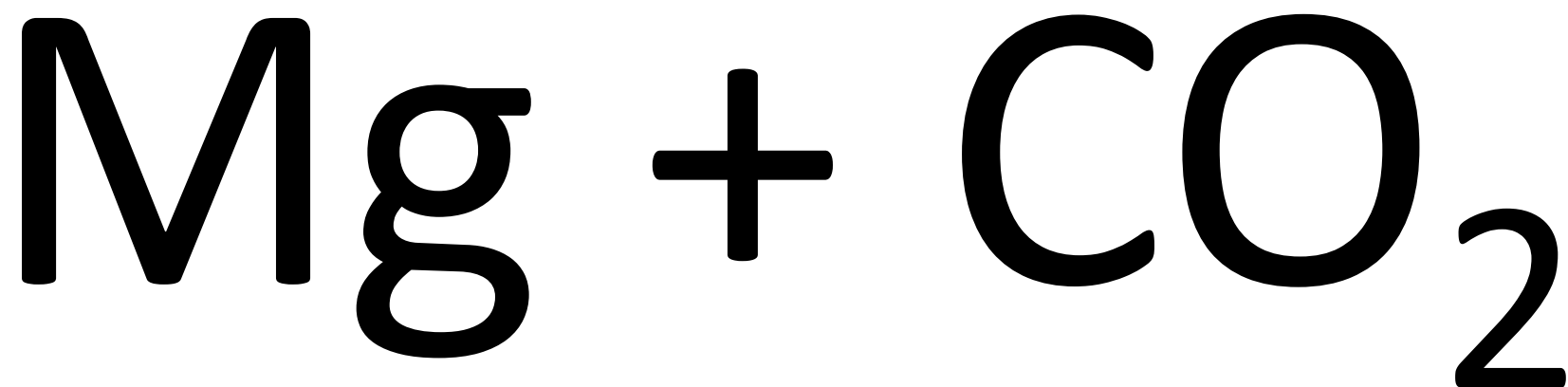
PI: Michael Paul (Penn State); with John Dankanich (Gray Research), James Kas/ ng (Penn State), Geoffrey Landis (NASA GRC), Tim Miller (Penn State), and Steve Oleson (NASA GRC)

$^{238}\text{Pu}$

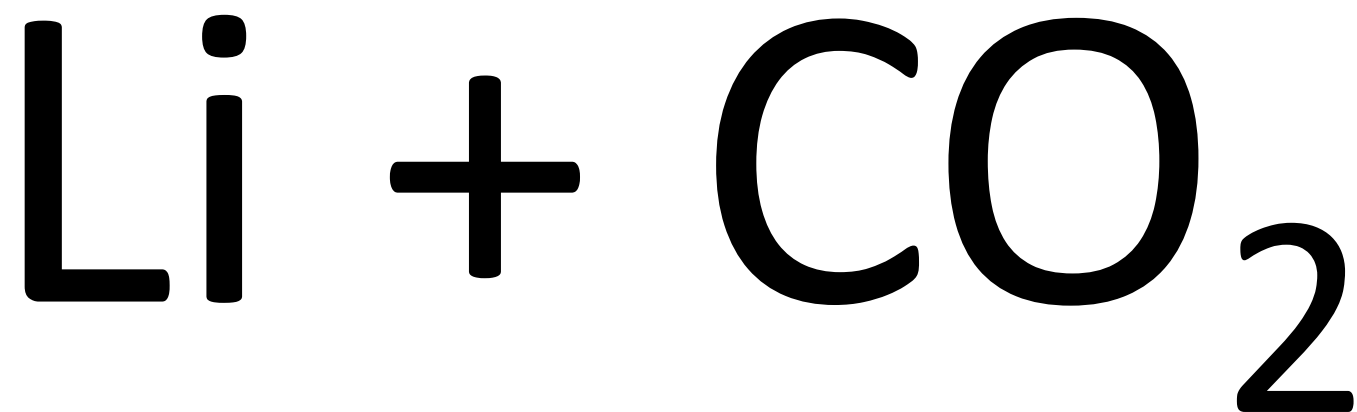














Credit: Marek Nikodem, Poland

2

120

240

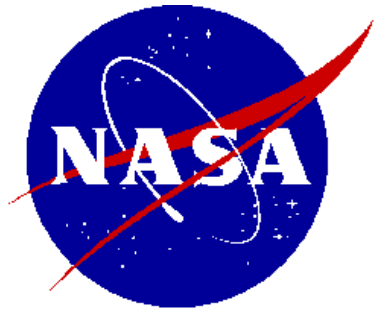
120

200 kg

850 kg



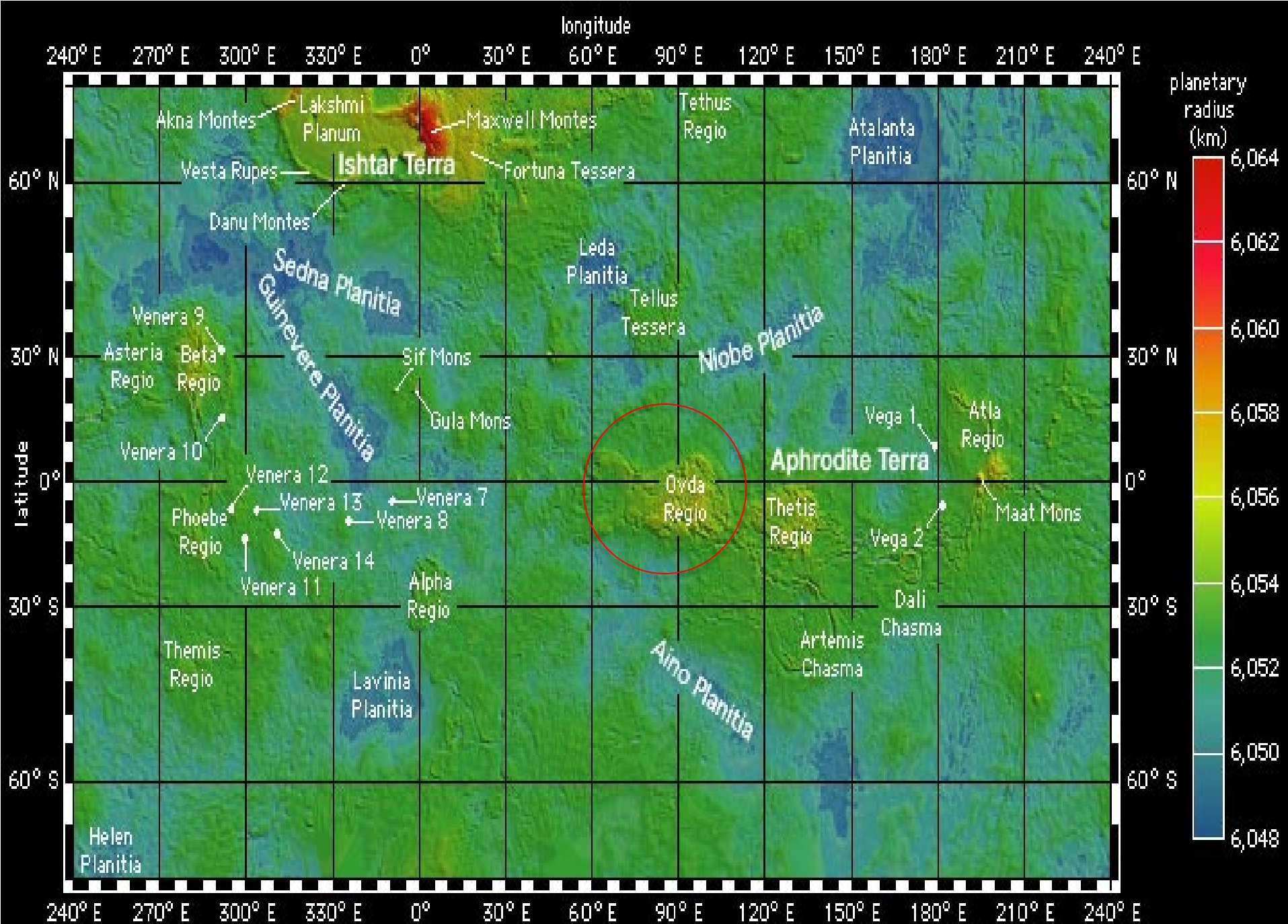
56 GPHS



***ALIVE!***

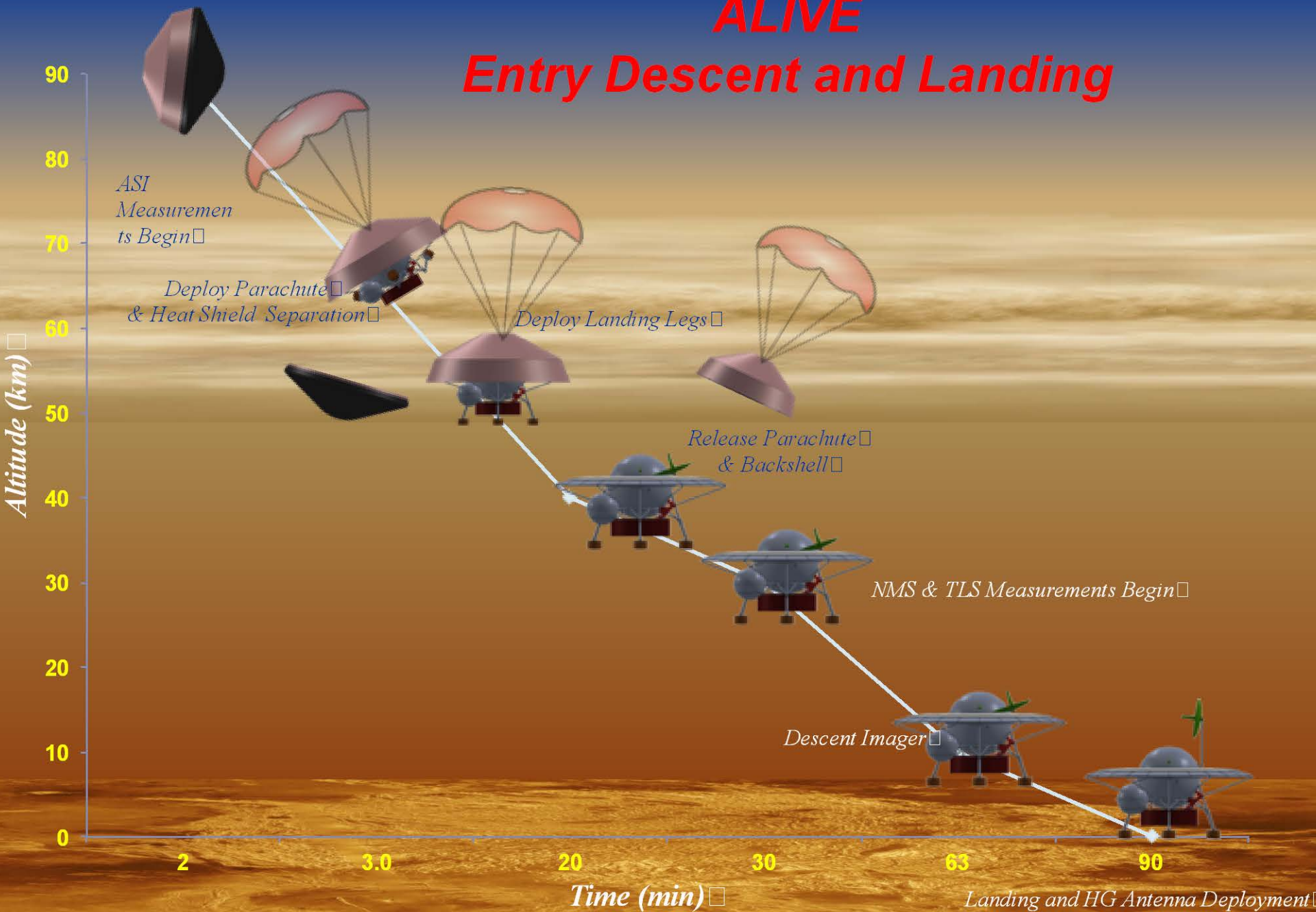
# **Advanced Long-life Lander Investigating the Venus Environment**





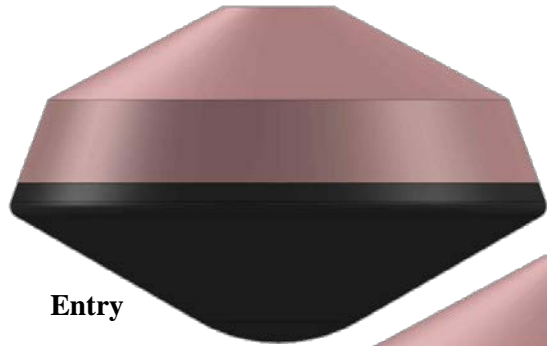
# ALIVE

## Entry Descent and Landing

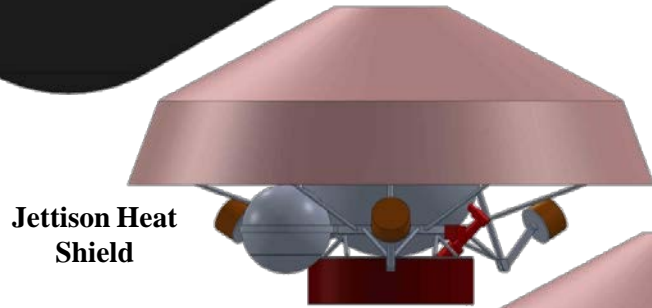


# ALIVE Science Goals

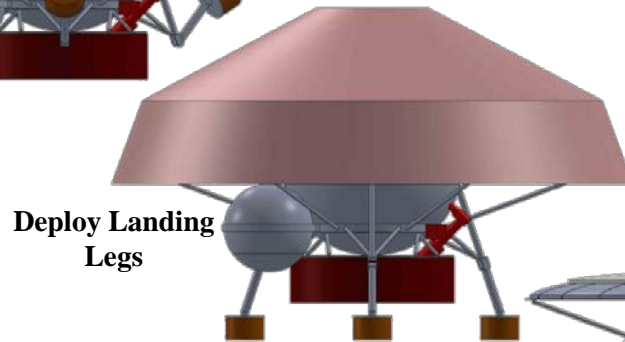
- *Atmospheric Structure Investigation (ASI)* – Starting at 90 km altitude; ten 12-bit measurements every 10m for a total of 1.1 Mbits of data, compressed at 10:1
- *Neutral Mass Spectrometer (NMS)* – Starting at 30 km; 300 measurements for a total 1.8 Mbits of total data
- *Tunable Laser Spectrometer (TLS)* – Starting at 30 km altitude, 300 measurements. Expected data volume: 3.6 Mbits
- *Descent Imager* – Used during the last 10 km of descent; 20 images; 96 Mbits (LOCO compressed)
- *Raman/Laser Induced Breakdown Spectroscopy (LIBS)* – Steerable, targets chosen by science team after landing; 5.2 Mbits per sample; 12 samples; Expected data volume: 62.4 Mbits
- *Context Imager* – 12 images at 20 Mbits each for a total of 220 Mbits; taken of targets for Raman LIBS
- *Panoramic Camera* – Two eight-frame panoramas for a total of 308 Mbits
- *Meteorology Data (ASI)* – Pressure, temperature, wind speed, sound speed; Operating at 1 bps for the duration of the science periods (27.6 hrs) for a total of 100 kbits



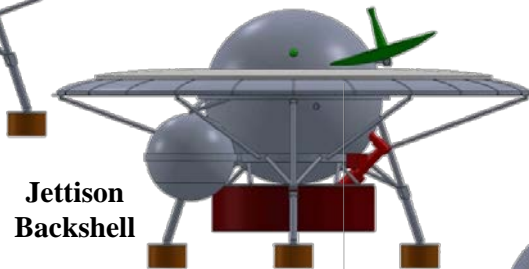
**Entry**



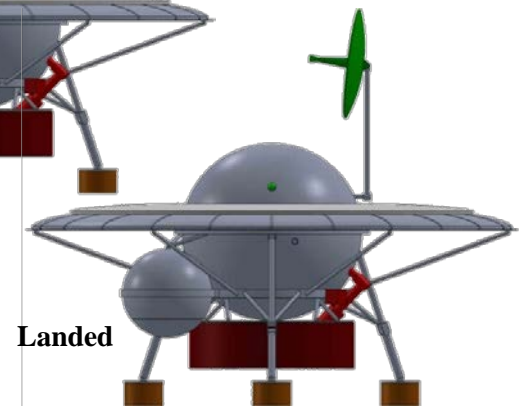
**Jettison Heat  
Shield**



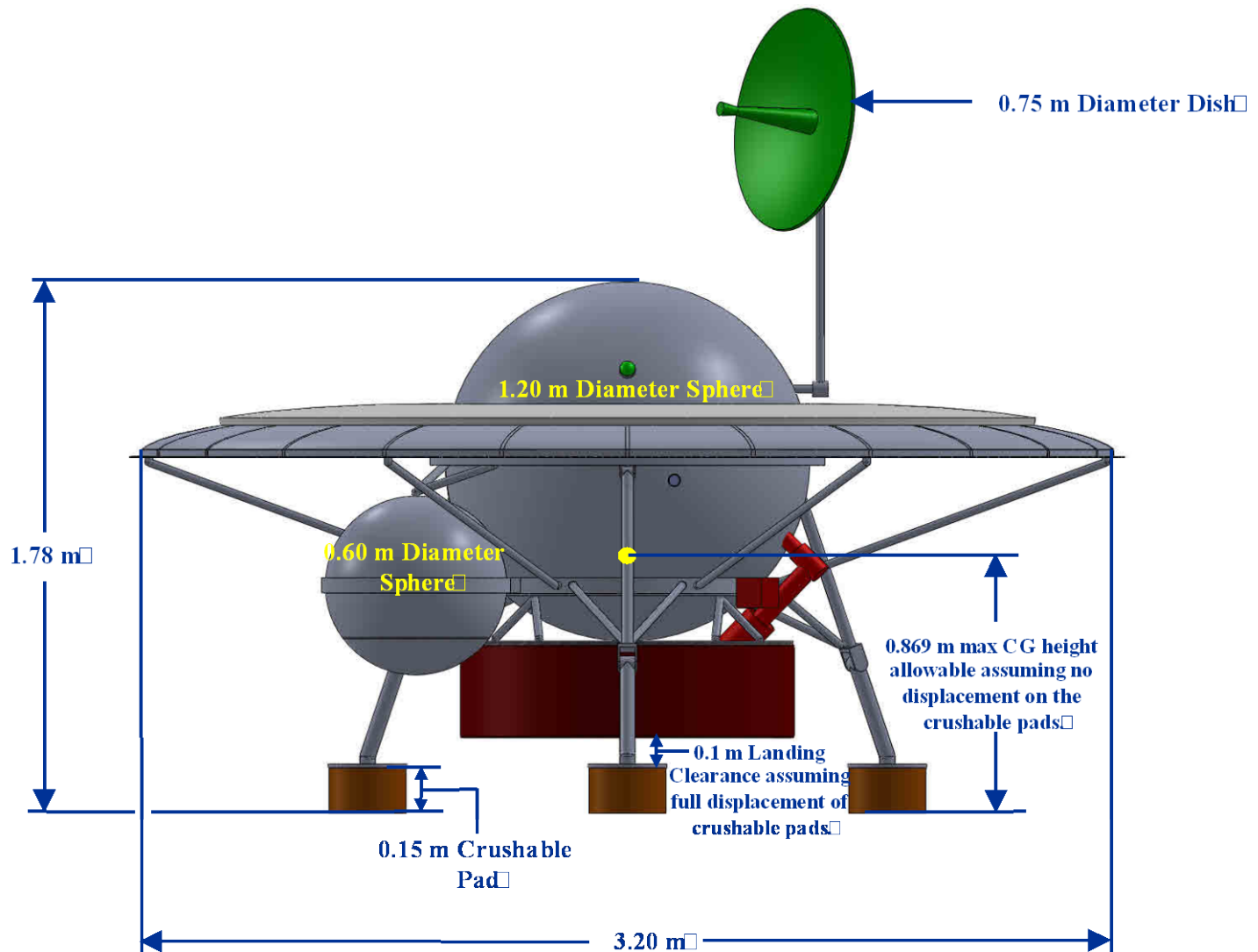
**Deploy Landing  
Legs**

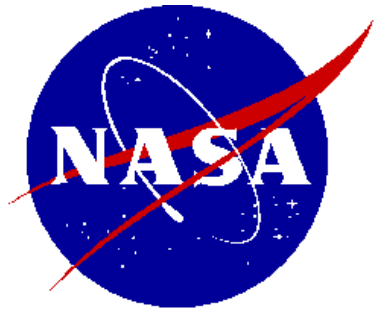


**Jettison  
Backshell**



**Landed**





# Thank you!

# Questions?

